

REMARKS FOR ADMINISTRATOR BOLDEN

59TH ANNUAL LOUIS H. BAUER LECTURE

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Thank you for inviting me to help kick off this 59th Annual Scientific Meeting of the AMA. Looking around the room, I'm very glad I finally got over being nervous around flight surgeons. This talk might be difficult otherwise.

This conference's theme, "Today's Challenges, Tomorrow's Opportunities," pretty much covers what we at NASA try to address every day.

We're in a brand new era of exploration -- one where we're advancing aeronautics and space technology development, transforming the ways we get to low Earth orbit, and setting our sights on farther destinations.

Today we celebrate the 40th anniversary of Skylab's launch, and NASA, probably more than any other agency, not only celebrates its history, we learn from it. We build on it, and we make ourselves better. And of course a lot of things we develop along the way don't just go up into space; they also come back down to Earth in the form of very real and practical everyday benefits.

Space technologies that have returned to our everyday lives include biomedical technologies such as advanced imaging and infant formula; potential new cancer treatments in the form of

microencapsulation; and the protective gear that keeps our military, firefighters, and police safe.

That trend is only going to escalate as we reach for even farther horizons. A human mission to Mars is today the ultimate destination in our solar system for humanity. NASA's entire exploration program is aligned to support this goal.

You may know that three years ago President Obama paid a visit to Kennedy Space Center, where he set goals of sending humans to an asteroid for the first time in history by 2025 and making a crewed journey to Mars by the 2030s.

A few months later, the President signed NASA's 2010 Authorization Act into law, extending the life of the International Space Station and committing the nation to fostering a growing commercial space industry.

These measures freed NASA to start work on building the next generation heavy lift rocket and multi-purpose crew vehicle needed to take our astronauts beyond low-Earth orbit into deep space, including that planned mission to Mars.

If anyone thinks that interest in human spaceflight has diminished since the end of the shuttle program, let me point out that last year we received the second highest number of astronaut applications in our history – more than 6,300. Less than 20 of them will make the final cut that will be announced in the coming weeks. These astronauts will be among the first to be trained specifically for long duration space flights.

Last year we also announced that NASA's Scott Kelly will undertake a one-year mission to the International Space Station in 2015. That mission will add to our knowledge of microgravity's effects on bone density, muscle mass, strength, vision, and other

aspects of human health. This research is essential as we plan for a long-duration flight to Mars.

Meanwhile, our commercial partners' continued successes in developing space transportation systems to low Earth orbit have demonstrated that our confidence in their approaches was well founded.

We now have one partner, SpaceX, regularly resupplying the International Space Station with cargo, while Orbital Science just test launched its *Antares* rocket and is set to become the second. Concurrently, SpaceX, Boeing, and Sierra Nevada are working hard to make commercial crew a reality by 2017, and I know they will.

This has allowed NASA to focus on the next destinations, including the asteroid mission that President Obama laid out for us in the FY2014 budget last month.

The new asteroid initiative is actually a broad asteroid strategy to identify and find out more about near-Earth asteroids, engage citizen scientists and new partners while we're doing it, and then ultimately send a mission to an asteroid that will relocate it to an orbit closer to Earth where astronauts can visit it using our Space Launch System and *Orion* multipurpose crew vehicle currently under development.

Our Space Technology Mission Directorate is hard at work on the technologies that are the underpinning of everything we do. This includes the solar electric propulsion that will power the robotic mission to bring our target asteroid nearer to Earth so astronauts can explore it and bring samples home.

The new budget also has a strong Science component, from increasing our fleet of Earth observation satellites, to sending new robots to orbit and land on Mars, to the James Webb Space Telescope targeted for a 2018 launch as the successor to the Hubble Space Telescope.

All of this reflects a human imperative to explore and learn. It can be dangerous, but we must not be too risk adverse. That's why NASA is doing the necessary planning and development to make space exploration as safe as it can be, and to make sure the things we learn in space have benefits on Earth as well.

As we plan those long duration missions to asteroids and other destinations, there are many extreme dangers we at NASA are trying to mitigate to decrease the risk to our crewmembers.

Among these risks are: radiation from solar particle events and cosmic radiation; microgravity-induced harmful changes in human physiology; and the consequences of isolation – be it the psychological effects of being away from family and friends or the problems with communication delays with Earth.

NASA is committed to human exploration of the solar system, and the health of our astronauts in preparation for their missions, during launch, and while they are in space, is our top priority. It is also important that space missions do not cause significant harm to crewmembers that might be seen only years after their space missions.

It's generally accepted that all radiation increases health hazards.

NASA has accepted the recommendation of the National Council on Radiation Protection and Measurements that was chartered in 1964 by Congress. The recommendation pertaining to radiation exposure states that astronaut radiation risk should not lead to more than a 3% increased death rate from cancer. This is in-line with other established risk limits for hazardous work, including military service.

Protons and cosmic radiation cause greater damage to human tissue than the usual terrestrial radiation sources. However, all the radiation risk information is based on terrestrial radiation risk, not with space protons or high-energy heavy ionized nuclei. NASA is working on getting more information in this area now.

It is estimated that on a three-year round trip to Mars, a cosmic particle would pass through each cell in the body once, and 2/3 would be hit twice.

The potential cancer risk is being determined; however, there is currently no data at all regarding the short or long term risk to the cardiovascular or central nervous system.

However, based on age, sex, and previous radiation exposure, NASA's model suggests that the allowable time spent in deep space could be as short as 200 days and as long as 500 days to protect against the accepted increased cancer risk.

Then of course, there's microgravity! We have all been raised in an Earth's gravitational environment and our health is based on gravity's presence in our daily lives. Take that away and a lot of things change. Any trip in space will reduce

gravitational forces on the human body. Among other things, this will decrease the forces that strengthen bones, muscles, and the cardiovascular system, induce new blood formation, and control input to the vestibular system for balance and positional sense.

Luckily, we have the world's only microgravity laboratory, the International Space Station (ISS), orbiting above us, and it's helping us understand the effects of living and working in that environment for long periods of time.

From my own experience in the Space Shuttle, I can tell you that microgravity certainly takes some getting used to. But now, we are beginning to develop a body of data since we flew the shuttle for 30 years, and we have had astronauts continuously in space aboard the ISS for more than 12 years. Prevention, mitigation, and rehabilitation technology and programs for the

maintenance of the human body in space will be essential for all our future missions.

Although Mars has $3/8$ G compared to Earth and work outside of a controlled environment will be performed in relatively heavy space suits, it is still not known if this level of G forces is above the threshold to protect human health.

It's fairly certain that a lot of exercise, though probably less than on the ISS, where astronauts have daily exercise as part of their routine, will be required on Mars. This would be important because less oxygen and food would be needed to maintain health while on Mars compared to deep space.

Traveling farther into space means isolation and confinement also have serious implications, most importantly, for behavioral health but also for environmental health.

Looking up from Mars at night, Earth is just a dot.

Astronauts will be foregoing day-to-day activities with their families and friends on Earth as well as participating in person in major life events.

There can be a 10 to 40 minute communication delay between Mars and Earth, so conversation may be very difficult with NASA and more difficult with family.

Humans have always explored, and so we have a lot of experience being separated from loved ones, but current and future research will focus on ways to mitigate this stress on astronauts and their families.

Now, think about what you pack for a vacation or other trip. Think about the choices you make. Now think if that trip was a year or longer and you couldn't stop at the corner drug store or a

mall to get something you forgot. Think about having to take your house with you. On any early missions to an asteroid or to Mars, we will need to bring all our supplies with us; food, water, air, medical equipment -- including diagnostic and laboratory instruments -- medication, exercise equipment, and other supplies. One thing we're researching right now is how to extend shelf life of foods and medications. We're also going to need to develop closed loop life support systems and to build on the knowledge we've gained on the ISS for recycling waste into potable water.

Additionally, we will have to provide some, if not all, autonomous health care. Medical training and, potentially, surgical capabilities, will be needed. Do any of you want to be an astronaut? We will need medical professionals on these long-duration missions. There's a reason Dr. McCoy was such a key member of the Enterprise's crew.

A little closer to home, something we've recently discovered is a change in visual acuity, which is the predominant symptom of increased intracranial pressure in long duration space flight. It wasn't discovered until about 8 years into the ISS program. Medical operations and the Human Research Program quickly developed methods to monitor and study the condition so that in the near future we will know how often to expect it, the cause of the problem, and how to prevent and, if necessary, treat this condition. If you're in space for many months, it's a problem that needs to be addressed.

NASA has done an exceptional job in identifying known health risks and using current biomedical knowledge to make spaceflight safe and to maintain crew health. We've invested in the new technology and research where necessary to expand medical knowledge.

However, we also recognize that we must ever be on the lookout for the “unknown, unknown”. That change in visual acuity, for instance, was not expected.

In the 50-plus years we've been sending humans to space, we've learned a great deal about the incredible stresses the human body endures while ascending to orbit, and also what it goes through in the deceptive calmness as one floats through space. You are, after all, traveling at about 17,500 miles an hour, for instance, just to rendezvous with the space station.

The human body is a marvelous, adaptive mechanism, but we need to address its needs in the new territory we're visiting. We're doing just that by research on the ISS, in our Human Research Program, and in many other ways.

I think everyone who has been to space would say it's worth it. Sailors suffered from scurvy until a solution was found. Pilots flying at high altitudes have had to make adjustments for extreme cold and lack of oxygen. Astronauts have had to endure unplanned extensions to their space missions due to human and natural events.

But Astronaut Suni Williams ran a marathon in space, circling the Earth many times while her colleagues on the ground pounded out their 26.2 miles. Astronauts have also participated in concerts from space, spoken live to classrooms around the world, fixed and upgraded their orbiting home, worked with a robotic crew member, and done countless other things that would not have been in the human vocabulary even 50 years ago.

All of you here in this room can help us overcome the challenges of living and working in space -- because the human

element is both how we explore and why we do it. I'm just one face of exploration. Right now there are just a few hundred others in the entire world who have seen Earth from outside the bounds of its atmosphere, but in the coming years, there will be many more. Your work will never be more important in keeping us all healthy as we do things that humans have never done before.

We at NASA are embarking on a grand venture of exploration and I hope all of you will want to join us on this journey.

Thank you.

